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KEYSTONE CENTER

THE IMPACT OF SCIENCE AND TECHNOLOGY R&D ON THE ECONOMIC HEALTH, QUALITY OF LIFE, AND NATIONAL SECURITY OF THE U.S.

A KEYSTONE CENTER POLICY CONSENSUS PROJECT

March 1988

INTRODUCTION

The United States' success as a world leader has been intrinsically bound with its long-established tradition of public and private support of science and technology. For over a century, since the federally funded land-grant colleges first initiated a strong coupling between researchers and farmers, America's ability to compete in world markets, assure her national security, and respond to the challenge of developing her own vast natural resources has been based on the nurturance of scientific and technological expertise. The public-private funding partnership which has underwritten America's success has also secured her place as one of the preeminent societies in world history committed to the development of scientific knowledge.

It has been a good investment. New technology has been responsible for nearly half of all gains in productivity since World War II, far more than gains due to capital, education, resource allocation, or economies of scale. Moreover, one has only to think of the blessings of medical vaccines, or to recall how the first pictures of the Earth taken from space forever changed our conception of ourselves, to be reminded of the many reasons for strong support of science and technology.

Reliance on the fruits of science presupposes a firm pledge to fundamental research: inquiry which has no demonstrable value beyond a clearer understanding of nature, but which also fuels breakthroughs that can alter the course of history. Public and private commitments recently have moved toward more product-oriented interests and priorities for R&D, obscuring a sense of definition of the appropriate role of science, technology and engineering in society as a whole.

The United States has witnessed its position in international trade and competition decline by as much as 48 percent since 1980. Its posture of innovation in many new areas of technology such as data processing, computer software, medicine, biotechnology, and space systems is now threatened by energetic competitors in the Asian and European scientific communities.

Current United States' defense and fiscal policy, in combination with a stagnant economy, have left this country struggling to redress its growing national debt and the resulting structure of deficit expenditures. The Gramm-Rudman-Hollings Act, conceived to discipline the entire federal economy, may further disrupt the delicate balance and commitment of resources necessary to insure success in science and technology research and development. This, in turn, could have dire effects on the nation's future competitiveness.

During the past eleven years, The Keystone Center has facilitated a number of policy dialogues focusing on many aspects of research and development in the U.S. Among the issues addressed have been the management of radioactive wastes, the impact of the tort system on product liability, U.S. energy futures, the role of the oceans in hazardous waste disposal, biotechnology regulatory policy, toxic exposure compensation, and the siting of hazardous waste facilities.

The insights into science and technology offered by the diverse participants in these projects have led The Center to conclude that it is time to take a comprehensive look at the impact of science and technology R&D on the economic health, quality of life, and national security of the U.S. The basic thesis is that the strategic, economic, and cultural well-being of the U.S. since World War II has been intimately related to our dominance in science and technology. We are losing this historic advantage, and must carefully reevaluate our policies to adjust to new political, economic, and scientific realities.

Work on this project has been encouraged by representatives of industry, academia, the scientific community, and interests within the federal government. In response, The Keystone Center is undertaking a policy consensus dialogue to address the fundamental concerns related to the impact of science and technology R&D on U.S. life. The goal is to develop consensus policy recommendations which can be used by key decision-makers in the Congress and the Executive Branch as they seek to balance national R&D needs associated with economic health, quality of life, and national security.

In preparation for such a project, The Keystone Center has held two planning meetings of a small steering group of scientists, educators, managers, and others both cognizant of the issues and interested in the subject. The intent of these preliminary meetings was threefold:

-to determine that there is an issue (or set of issues) within this subject area which deserves discussion;

-to articulate the problem or to focus on one aspect of the problem; and

-to develop an approach and a plan for The Keystone Center dialogue on this subject.

The results of that process comprise the body of this report. The participants (see Appendix A) agreed that there is a worthy subject for The Center to pursue in a consensus dialogue. They outlined the issue and formulated several succinct statements of the problem. They agreed that the entire suite of issues within the subject needs exploration at some level, but they focused on three themes. And, finally, they assembled an action plan and schedule for the work of the consensus dialogue.

STATEMENT OF THE PROBLEM

The title of this report--"THE IMPACT OF SCIENCE AND TECHNOLOGY R&D ON THE ECONOMIC HEALTH, QUALITY OF LIFE, AND NATIONAL SECURITY OF THE U.S."--is our statement of the scope of the issues to be considered. In that title are both the theme (science and technology R&D) and the national goals at which R&D are necessarily directed. One way to focus within this scope is to ask the question -

> CAN THE GENERAL WELL-BEING OF THE U.S. BENEFIT FROM A GREATER FOCUS ON SCIENCE AND TECHNOLOGY?

The answer is not apparent. Many of us believe that the answer is "Yes." But there are clearly doubts.

While there is general agreement in the news media, the scientific literature, and the reports of panels like the National Academy of Sciences that our national well-being is tied to science and technology, the issue is usually framed within the individual viewpoint of some vested interest. For businessmen it may be competitiveness in international markets. For educators it may be the lack of interest by U.S. students in science and engineering curricula. For government agencies it may be the lack of funding for favorite programs. For many it is a matter of balance.

> THE CONCERN IS THAT THE NATIONAL RESEARCH AND DEVELOPMENT PROCESS AND PRIORITIES ARE INADEQUATE TO SUPPORT INTERNATIONAL COMPETITIVENESS, AND MAY ULTIMATELY LEAD TO A DECLINE IN U.S. ECONOMIC HEALTH, NATIONAL SECURITY, AND QUALITY OF U.S. LIFE.

The paradigm that money spent on research "trickles down" to the market place is now being questioned. We clearly do not understand in any depth the way that process works, but sense that it may be too inefficient or too slow or too uncontrolled. A review of history and some other, more modern, models is clearly warranted.

> THE ROLE OF SCIENCE AND TECHNOLOGY R&D IN THE ECONOMIC SECURITY AND SOCIAL STRUCTURE OF THE U.S. CONTINUES TO SUFFER FROM CHANGING DIRECTIONS, CHANGING POLICY, CHANGING BUDGETS, AND CHANGING REWARDS FOR ITS PRACTITIONERS. THIS LEADS TO ADVERSE EFFECTS ON THE HEALTH OF THE SYSTEM.

The two assertions and one question highlighted above are our best present formulation of the "problem". There are many others that come from individual viewpoints. The "system" in which science and technology R&D resides is not simple, and the above statements together with the plan that follows are meant to explore all parts of that system.

BACKGROUND-THE ORIGINS OF U.S. SCIENCE AND TECHNOLOGY POLICY

With the relation between a healthy research base and the strategic, economic and cultural well-being of the country so firmly established in the American mind, it is surprising that America has never explicitly formulated a national policy for the funding of science and technology. What substitutes for one is the paradigm of U.S. investment in research and development during World War II, and the societal benefits that followed.

The war represented a major turning point in the government role in American science, and nothing has been the same after it. By comparison, all the changes that have taken place in the last forty years seem minor. Thus, in order to see in perspective the major challenges facing current science policy, it is useful to consider how World War II shaped American thinking about the role of science and technology in society.

To create new supply for the war effort, the government stimulated rapid development of new productive facilities in many industrial sectors by spending on an unprecedented level. The response was dramatic: in only five years the nation's annual output increased by more than a hundred and twelve percent. Many of the new technologies created or stimulated by the war, such as electronics, petrochemicals, aircraft, steel, and nuclear power, became the major industries of America's postwar prosperity. And the success of the Manhattan Project, in particular, indelibly imprinted the way in which the most esoteric science might lead to spectacular technological developments.

This understanding of the role and potential of science was cemented in the postwar years by the famous Vannevar Bush Report of 1947, "Science the Endless Frontier". The report, which has remained in many respects the national charter for science policy, has been likened to a social contract between science and society--a promise of social benefits in exchange for an unusual degree of self-governance and financial support, granted by society to the scientific community. Technology, the report seemed to say, is essentially the application of leading-edge science, and by creating and sustaining a first-class science establishment, the country could ensure an almost automatic flow of new technology for national security, economic growth, and social welfare without explicit policy attention to all the other complimentary aspects of innovation.

Such a simplistic description of the process of innovation was probably not believed by the authors of the report; but the notion that ideas flow one way, from fundamental and applied research through technological development to culminate in commercial application, received triumphant confirmation in the very year the Bush Report was delivered. The transistor was developed at Bell Telephone Labs in 1947. In every way, it was the direct result of fundamental and applied research in semiconductor science. When the exploratory and advanced development which made the transistor and integrated circuit such powerful engines of innovation followed without apparent need for intervention, the agenda for discussion of science policy was set.

This has been an immensely productive model which has helped bring the U.S. to a position of scientific, military, and economic world leadership. But many things have changed since World War II, and it is not clear that the old model is still an adequate basis for decisions about science policy. Many sense that we do not understand at all how this machine really works. Other nations are rapidly improving their standards of living relative to ours with the guidance of quite different policies. There are extraordinary new pressures on the scientific and technological enterprise and on the governmental and private resources which support it. America's expensive military remodernization and its weakened economy are squeezing research funds just as the country turns to the scientific community for answers to its strategic and competitiveness problems.

It does not promise to be a time when balanced thinking about the national interest will occur. Nevertheless, since the problems involved penetrate to the core of American society in so many ways, a comprehensive consideration of the issues surrounding the impact of research and development in science and technology may be the only way we can safely consider the future.

BACKGROUND-THE IMPACT OF U.S. SCIENCE AND TECHNOLOGY R&D

For the purposes of discussion, the many pieces of this topic have been grouped under four broad headings. This is an attempt to integrate the discussions of the two Keystone meetings with relevant articles from the scientific and technical literature. In reality, of course, the issues interpenetrate in so many ways that all divisions of the subject are arbitrary. That is one of the reasons for exploring the possibilities for a more comprehensive national policy.

1) ECONOMIC HEALTH. The American economy has found itself abruptly tethered to the larger World economy, in which it is

faltering. Discoveries in basic sciences, wherever they are made, quickly become international property. Thus, the link between science and economic benefits is broken unless American discoveries can be rapidly and efficiently turned into goods and services. If others do it better, the logic of an open world market relentlessly causes advanced production to gravitate elsewhere.

America is still the world leader in most fields of basic research, but we have not done nearly as well in the economic competition. Our alarming $170 billion per year trade deficits have placed 'competitiveness' on every agenda for discussion. One thing most analysts agree is important is that despite leading the world in overall investment in research and development in many sectors of science and technology, our industrial productivity has grown at the feeble rate of 0.4% per year since 1979. Other nations, while spending less on the effort, have increased productivity three to nine times as fast. This, in combination with the strong dollar and high cost of capital in recent years, has seriously undercut the ability of many U.S. industries to compete in the international arena. Such developments have raised fundamental questions about our research priorities, the coupling between science and technology in America, the short time-horizons on which American government and business operate, and about the relation between fiscal and science policy.

The Reagan Administration has responded to the weakened economy by taking steps designed to concentrate federal funding on those sciences with the highest potential for payoff in new technologies. In one instance of this, the President's FY 1988 budget proposes a 17% increase in the NSF budget to support a major initiative to establish university-based interdisciplinary research and technology centers directed to problems of national needs and relevant to industrial technology. These centers promise a cross-fertilization between industry and academia with potential for improving the efficiency with which American discoveries are turned into commercial products. University researchers will gain access to expensive equipment which is difficult to get and maintain in a university setting, and industry will be able to explore problems requiring long time scales and having less immediate relevance to product development.

But, supporting such centers in a time of budget cuts requires a reallocation of funds from other research and development projects. Some observers caution that the new centers are quite similar in concept to the generic research centers begun at the Commerce Department during the Carter administration. The same short national attention span which terminated that program in 1981 could cripple the new initiative when 'competitiveness' moves off the front pages. University researchers worry that a highly structured, short term payoff climate would stifle the creativity which has been the hallmark of academic research and which has been so valuable both in absolute terms and in terms of the type of students it produces.

These issues pose several questions:

-Should R&D funding objectives be prioritized, and if so, how? What improvements in the process of setting funding objectives could be made?

-Is it possible or prudent to discriminate between sciences that do or do not lead to more technology?

-How can the science and technology community get greater efficiency out of limited R&D funds in a time of budget cuts?

-Should the U.S. target certain fields in which it will concentrate efforts to become or remain a leader?

-What new institutional arrangements for research will best serve the national needs, and how will they be funded? What is the state and regional role in funding these centers?

-If multi-disciplinary centers hold a key to U.S. competitiveness, what fields should the centers involve?

-To what extent should American industry participate in joint international research ventures?

We have been accustomed to think of new technology as the fruit of scientific advances while tending to forget that it is economics that determines whether it is profitable to innovate or not. The cost of capital in America has been more than twice as high as in Japan in recent years; a powerful disincentive to investment in the long-term development of new technologies, especially when coupled with the short-term, 'next quarterly report', preoccupation of American business managers. Again, several questions arise:

-Should science and technology policy be integrated with fiscal and monetary policy, and if so, how should it be done?

-Are there fiscal policies that would enable U.S industry to match the willingness of foreign industry to dedicate people and money to long term R&D projects?

-Is it desirable to devise a system of tax incentives to businesses involved in research and development?

-How can the proprietary rights of corporations investing in R&D be protected?

-What are the appropriate governmental and business roles in supporting long-term, high-risk development efforts whose payoff horizons lie below even the lowest possible cost of capital?

2) NATIONAL SECURITY. America carries a defense burden not equally shared by her trading partners, so a crucial question in U.S. science and technology policy is how resources are to be divided between research for national security needs and research which supports social and economic needs. Defiantly narrow commitments to defense may so endanger our social and economic security that genuine national security will suffer. At the same time, unrealistic expedients to improve economic strength may so undercut deterrence that our freedoms and alliances will wither.

Funding of R&D takes place within the context of this larger debate, and, not surprisingly, the historic military/civilian split has reflected the national mood. From the beginning of the Cold War in the late 1940's until about 1967, public concerns and political debate about national security were the driving force that determined the growth of science as a whole. The launching of Sputnik in 1957 and the race to the moon intensified the defense effort. As a result, even though funding for such fields as biomedical sciences increased by as much as 30% per year, spending for defense, space, and nuclear energy accounted for more that three quarters of the federal R&D budget. This level peaked at 93% in 1963. It is noteworthy, though, that defense and civilian needs were rather more similar during that period than they are today, and a large share of defense spending went to basic research in universities with few requirements to show relevance to weapons systems and the like.

After 1967, the technical success of military and space programs had heightened the public expectation that science should solve such social problems as the decay of American cities, deterioration of the environment, and the depletion of energy sources. During this period of socially relevant research, the military share of all federal R&D fell to about 50%.

The modern era of science funding began in 1980 with the Reagan administration's renewed commitment to national security. Between 1980 and 1987, annual federal outlays for military R&D rose from $17.8 billion to $35.8 billion in 1985 dollars. Federal non-military R&D funding fell during this period from $20.8 billion to $16.5 billion per year. This represents a return to the 70/30 military/civilian split of the 1950's and 1960's. However, because the composition of military R&D has been altered, the meaning of this division of federal funds has changed significantly in the intervening years.

The proportion of military R&D funding devoted to basic research has been declining since the Mansfield Amendment, in 1971, limited the Defense Department's role in research to projects that could be specifically tied to a military need. Although the amendment no longer applies, the attitudes it engendered live on.

Military R&D, always dominated by development rather than research, has gone from 74.2% development in 1965 to 90.1% today.

And such is the preponderance of defense in federal R&D that overall support for basic research has fallen since 1980 despite a near doubling of the proportion of non-defense research dollars going to basic research.

Industrial R&D spending has grown rapidly in the last decade, reaching a level roughly equal with federal spending at $60 billion in 1987. Here too, however, the emphasis is on applied research and development rather than fundamental research. We may be chronically underfunding basic research.

There is another difference between current defense R&D and that of thirty years ago: investments in esoteric modern defense technologies do not readily produce 'spinoffs' in the commercial sector. Aside from the strategic defense initiative (SDI), which is partly focused on advanced technologies with potential for significant economic benefits, and projects in the Defense Advanced Research Projects Agency (DARPA), most military work is concentrated on short range development efforts. Moreover, the transfer of the technological products of defense research to the civilian sector is often impeded by the classification of crucial information. An important question is how to promote technology transfer to American industry without endangering national security.

If funding for defense work is removed from the R&D figures. our civilian R&D level is below that of both West Germany and Japan; a fact which does not augur well for our future economic success.

One way to understand where the balance has been struck at present is to consider funding for the strategic defense initiative. The President's 1987 budget request for $5.4 billion was cut to $3.5 billion, and the 1988 request for $5.8 billion will most likely get similar treatment. Nevertheless, the reduced figure is still twice as large as the entire NSF budget. Since total federal R&D spending has fallen 10% over the last 20 years, such important societal choices are not abstractions; they should be made with a broad understanding of the trade-offs involved. The composition of the scientific community changes as young scientists make career choices influenced by the availability of funds. Department of Defense engineers are distributed among disciplines in the same way as civilian engineers, but in sciences, the ratio of physical to life scientists is much higher in the DOD than in the civilian sector.

Thus, the high priority given military research, when coupled, for example, with the reduction in the budget for the NIH, threatens the deterioration of the world's finest biomedical research enterprise.

We do not propose to have the Keystone policy dialogue enter the national security debate. However, there are issues involving the military/civilian split which are fundamental to any national policy on funding science and technology R&D.

-What are the tradeoffs involved in shifting R&D funds between the military and civilian sectors?

-How much emphasis should the nation put on basic research, and where should that research be done?

-How can adequate investment in basic and applied research be assured during a time of budget cuts, when the majority of funds are used for military or industrial needs?

-Since there is a fundamental assumption that defense R&D will provide 'spinoffs' to the private sector, how should decisions be made about declassifying information for the use of American industry?

-Are there possibilities for broader and crisper scientific analysis of the major R&D related decisions in defense management?

-How much technical assistance do Congressional committees involved with these issues need, and how can they get it?

3) CHANGES IN SCIENCE. There are several reasons why the demand on federal funds for basic scientific research is increasing. Research opportunities have been vastly expanded by new instrumentation and methodological leaps, with a resultant increase in the annual cost per researcher that grows faster that the consumer price index by a factor of about 1.6. And new scientists are highly likely to go into the capital intensive new research areas.

Expanding demand in a time of strong fiscal constraints on federal expenditures has resulted in an even more that usually competitive atmosphere within the scientific community. Historically, 'small science' has not fared as well as 'big science' in such times. Recent budgets have allocated an increasing percentage for big science projects, driven both by scientific opportunity and political expediency. Most fields have an enormous project, each with supporters and detractors: physics has the $6 billion superconducting supercollider; NASA has the $14 billion space station and the $2 billion Hubble telescope; and biology has the multi-billion dollar human genome mapping project. These big science projects exploit important scientific opportunities and promise major advances in our understanding, but, since they compete for funding with small science, they involve difficult choices.

Small group research remains at the heart of our national university programs. The majority of the technical manpower needed for industry, defense, and academia is trained in small science areas, and the new engineering and research centers have expanded the opportunities for carrying out such research at the fertile margins where disciplines overlap. Underinvestment in high-risk research may partly explain why many recent breakthroughs have been made abroad: the Quantum Hall effect; the scanning tunneling microscope; and the new high Tc superconductors.

Theory, which is usually 'small science', is needed to guide the direction of 'big science'. Moreover, experimental areas of big science depend on advances in small science. For example, $1.1 billion of the SSC budget is allocated to superconducting magnets. A relatively small investment in the new high Tc superconductors could perhaps significantly improve the future performance of the SSC, and, at the same time, also have a major impact on electronics and communications.

The development of new instrumentation, which has so enlarged opportunities for research, has also made old facilities obsolete. A large share of the funding for R&D over the last 20 years has been made available by not updating the academic research infrastructure. The present distribution of responsibility for such construction, which leaves the federal government without an explicit role, yields a system in which $4 billion a year is spent on research undertaken in facilities that are poor to fair at best.

The assignment of research priorities raises another set of questions:

-How can priorities be set in cases where 'big' and 'little' science compete for the same funds? What policies would assist in assessment of the trade-offs involved. Might the OSTP play a role in the process?

-Should federal agencies have clearly enunciated policies that state the reasons why they support basic and applied research, and define the domains of research they support?

-How can the responsibilities of different agencies and organizations be assigned when they collaborate on complex large-scale projects?

-In large projects involving sensitive technologies, who should clarify the fuzziness regarding what is classified and what is to be freely released?

-What should be the government role in assuring the health of the academic research infrastructure?

4) EDUCATION. Underlying the entire concern for the future funding of U.S. science and technology R&D is the question of education. Science cannot deliver its promise to society if we do not train the people needed for the job; but recent trends suggest that this is not being done well enough. Fewer and fewer students are entering sciences, and, of these, more and more come from abroad. Since 1981, more than half of all Ph.D. degrees in engineering, math, and physics in the U.S. have been awarded to foreign students, and the proportion is rising. More than 85% of the recent growth in science and engineering graduate enrollment is attributable to foreign students.

These trends make it apparent that the U.S. must find ways to develop and draw on the talents of all segments of its society. However, while the R&D manpower pool has included a constantly increasing fraction of the labor force in the other advanced nations, the U.S. percentage has declined over the last two decades. Particularly worrisome is the fact that women and minorities are underrepresented in technical disciplines by a factor of ten, and the trend is negative. Shortfalls in crucial industries and disciplines are predicted for the coming years. When industrial managers are surveyed about this situation, they almost uniformly recommend more national emphasis on basic education in science and math. Nevertheless, the requested Department of Education FY 1988 budget eliminates its science and math education funding and its Women's Educational Equity budget.

At the NIH, flat funding allows inflation to continue the erosion of the Small and Minorities Institution program.

The federal government has encouraged a greater acceptance of R&D funding by the private sector, with good results. Half of all R&D monies now come from private industry. This has resulted, however, in a slump in graduate enrollment because industrial positions are now so attractive to baccalaureate recipients. And the number of Ph.D.'s in industry has increased at more than twice the rate that it has in academia during the last ten years, raising concerns that the research fabric of the universities will be weakened as talent is drawn into the private labs.

The questions concerning education are fundamental to the discussion of science and technology policy.

-Who should be responsible for assuring the quality of science and engineering education in the U.S.? What sources and methods of funding would be most effective in reaching the goal?

-Should the U.S. be targeting the development of certain types of scientists and engineers, and if so, in which fields?

-Are too many universities trying to be involved in every area of science and technology, and would it be in the national interest to designate some as special centers of excellence in selected fields?

-Should the U.S. develop tax or patent incentives to allow researchers to innovate while remaining in university or national labs?

-What part could public education play in fostering a broader understanding of the role of science in society?

THE ISSUES

From the two planning sessions the Keystone participants have extracted a set of issues and assembled them into a structure for discussion in the course of the project. Presupposed in the selection of issues is the premise that the U.S. should somehow maximize the beneficial impact of science and technology R&D on the well-being of the U.S.. The issues fall naturally into three categories-- policy, institutional structures, and the overall environment and value systems in which R&D is carried out. Each is a major part of the larger system in which the R&D resides.

1. FUNDING POLICIES AND ROLES OF EACH SECTOR

A. Defense

-Defense/Civilian split. How resources are to be divided between research for national security needs and research which supports other social and economic objectives.

-Big vs. Small Science. How can a balance be struck between support for enormously expensive projects such as the SSC, and support for individual investigators?

-Long term directions for R&D. Would strategic planning for R&D enhance the impact of science and technology on U.S. life?

-Programmatic Structure. Could changes in the structure of defense programs lead to greater efficiency and production of weapons systems which better support national security in the broad sense?

B. Civilian

-Policies to promote risk-taking in research. Are there policies that would encourage investigators to pursue risky, long-term research agendas if they considered the potential benefits great enough?

-Is the grantmaking process adequate? Can the peer review process be improved on?
Role of bootlegging in the distribution of funds. Many consider such 'benign' transfers of funds as an indispensable flexibility in the system. Is this appropriate?

-Pork Barrel science project funding. Is this intolerable Congressional meddling in the distribution of funds or is it the only way that promising projects in certain areas can get the funding they need?

-Priorities for research and standards to use. Should funding agencies set priorities for research and establish standards to judge the quality of the research funded?

-Increasing cost of doing science. Costs have risen much faster than in the rest of society, with the result that the level of actual support is lower than in 1965, despite what appear to be substantial increases.

C. Industry

-Process technology. Need for increased attention and funding for the process whereby ideas are turned into finished products.

-Investment in long-term/short-term payoff research. Development of sources of low-cost venture capital to fund research with long payoff horizons.

-Total dollars into R&D. Consideration of tax structures, tort laws, trade barriers, proprietary rights, regulatory stability, and fiscal and monetary policy.

-Priorities for research and standards to use. The Japanese fish in our pool of basic research and pull out quite different things to concentrate on. Can we do this better?

2. INSTITUTIONAL POLICIES, STRUCTURES AND ROLES

A. Government

-Need for strategic science policy. Should the U.S. formulate a strategic science policy, and if so, how?

-Global Security. U.S. national security and economic health is closely linked to the health and security of many other nations, so an 'island U.S.' mentality is counterproductive.

-Role of the National Labs. What part do the various national labs play in promoting economic health, quality of life and national security?

-Integration of fiscal and monetary policy with science and technology policy. The cost and availability of money does much to determine what sorts of research get done, so perhaps there should be some formal link which keeps R&D needs in the minds of fiscal and monetary policymakers.

-Role of the Science Advisor. Would an influential science advisor serve to improve the state of the U.S.?

-Level international playing field. What is needed to allow U.S. corporations to compete on an equal footing with foreign competitors?

-Global information access. Does the rapid spread of information on a global scale necessitate new policies for protecting innovation?

B. Industry

-Technology transfer. What changes could U.S. corporations make to do better in the race to commercialize inventions?

-International cooperative projects. What is the potential and what are the pitfalls of joint ventures with foreign corporations?

-Horizontal technology transfer among sectors. How and when should new discoveries be transmitted to other groups who could put them to use?

-Technology push/Market pull. How do these two factors interact to determine R&D priorities?

C. Academia

-Development of talent. How should the educational system be improved to insure that there will be an adequate supply of trained scientists and engineers?

-Public science literacy. How can the public understanding and appreciation of the role of science and technology in society be enhanced?

-Technology transfer. What links between university labs and industry are necessary to help commercialize innovations?

-Interdisciplinary programs. Where can students learn to explore the fertile margins between the disciplines?

-Replacement of facilities. With tight budgets and rising costs of instrumentation, how are the universities to replace the large fraction of their infrastructure that is outdated?

3. REWARDS TO/VALUES OF INDIVIDUALS AND INSTITUTIONS

A. Government

-Promoting innovation. How can taxes be structured and proprietary rights protected so as to increase the rewards to innovators?

-Grantmaking. What is the potential for enhanced innovation from long-term, high risk grants to outstanding investigators?

-Developing the talent pool represented by women and minorities. By the year 2025 the U.S. population will be predominantly young and brown skinned. What are we doing to bring them into the sciences where they are badly under-represented?

B. Industry

-Reward system. What are the incentives and disincentives to innovation?

-Protection of proprietary rights. How can international proprietary rights be protected?

-Cost and availability of capital. Is it possible to develop sources of venture capital at reasonable cost?

C. Academia

-Incentives to innovate while in academic posts. What sorts of changes in universities and grants would allow investigators to profit from innovation while remaining in academic posts?

-Tenure structure. Can teachers who concentrate on teaching rather than publishing be allowed the same security as those who do more research?

-Grantmaking process. Does the awarding of grants adequately reward outstanding teachers and researchers?

PROJECT DESCRIPTION

The Keystone Center, a national non-profit organization located in Keystone, Colorado, seeks to enhance public understanding and governmental decisionmaking in critical areas where science and broad public purposes intersect. The principal tool developed by the Center is the policy dialogue: a forum which has proven luseful in aiding the creation of consensus on complex national issues. The Center's projects have received wide attention, both for the quality of the results and the exciting nature of the consensus building involved in the dialogue process.

Experience has shown that agreements produced through a broad based consensus process can have a significant impact in the policy-making process. The goal of this project will be:

> To seek to develop consensus on national policy and goals for the future funding of U.S. science and technology R&D in a more systematic and comprehensive fashion than has traditionally been undertaken, keeping in mind the balance necessary to assure the strategic, economic and cultural health of the nation, while preserving the vital mechanisms of the private enterprise system.

To accomplish this goal, the following objectives will guide the development and execution of the project:

-The project will seek to produce influential recommendations through the involvement of key decisionmakers from all interested and affected parties.

-It is acknowledged that strong differences of cpinion do exist on various aspects of this issue, and the project will not attempt to 'solve' these, but rather to explore areas where the potential for agreement may exist.

-Areas where action can be agreed upon, as well as those areas where consensus is currently not obtainable and which need further work, will be defined. In these latter cases, the problems at hand often can be presented clearly and insights for future action can be outlined.

-To make every effort to complete the project in a timely fashion so that any agreements and/or recommendations can contribute to policy formulation and implementation processes in the most effective way.

Policy dialogue meetings normally involve fifteen to fifty people from academia, industry, citizen and environmental groups, local, state and national government, and other relevant professions. Participants are asked to attend as individuals, not as representatives of groups, organizations, or specific interests. The emphasis is on problem definition, identification, and understanding of basic policy goals and objectives, and the discovery of new alternatives that may, in time, aid in the creation of state and national policy. It is the blending of scientific concerns and the formulation of innovative approaches to critical public policy concerns which characterize the past work of The Keystone Center. The process allows participants the opportunity to clarify and refine their positions, while at the same time increasing their understanding of the goals and viewpoints of others.

PROJECT DESCRIPTION--WORK PLAN

The Keystone project on "THE IMPACT OF SCIENCE AND TECHNOLOGY R&D ON THE ECONOMIC HEALTH, QUALITY OF LIFE, AND NATIONAL SECURITY OF THE U.S." will be carried out as a series of meetings to discuss several aspects of the issues. These will be organized into three series:

-a series on strategic policy;

-a series on the process of technology transfer from research to goods and services;

-a series on education and the cultural environment in which R&D resides.

The strategic policy series will explore ways of promoting the health of the scientific and technological establishment. Topics include such things as considering whether we need a national science policy and how one should be arrived at. What changes in institutional structures would help shape better science policy? And what improvements could be made in the way goals for science policy are set?

This series will consist of three meetings to which we will bring additional experts from industry, government and academia who deal with the formulation of policies for their own R&D programs.

We have settled on three meetings because the issues within this series will likely be contentious and because we will need to explore institutional issues in some depth.

The focus of the first meeting will be whether we need a national strategic science policy and how we might best arrive at one.

The technology transfer series will deal with the problems that occur in transferring technology from research lab to products and services. It will also deal with the problems in transferral of technologies from one sector to another, eg. from government labs to the private sector. It will explore the innovation/commercialization process, the barriers between sectors, incentives and disincentives for innovators, and the overall adequacy of R&D funding.

We expect that these subjects can be covered in the course of two meetings, with participants drawn from industry, university and government labs. The first will focus on the innovation/commercialization process, relations between sectors and incentives for investigators. The second will be concerned with the adequacy of funding.

The education series may be a single meeting, but...the meeting will cover such issues as the increasing proportion of foreign nationals in graduate programs, the lack of rewards for researchers to press their ideas to products, the quality of science education, and the need to develop the talent pool of all segments of society.

Participants for this meeting will be drawn from major academic institutions, sponsoring agencies and industrial laboratories.

PROJECT STAFF

The Keystone Center staff will be augmented by two individuals. Dr. William P. Bishop, Vice President, Science Applications International Corporation will act as 'Senior Project Leader' to provide guidance to the project. Dr. Bishop brings 25 years of leadership as scientist and administrator in national laboratories and the government. He has also been a participant and discussion leader in The Keystone Center policy dialogues since 1982. Dr. Willard L. Hedden will provide the day-to-day project direction as 'Project Leader'. Dr. Hedden is a Program Associate to The Keystone Center. He brings 15 years experience as scientist and 10 years of facilitating discussions on environmental and science policy. Bob Craig, who has been pursuing this not-so-holy Grail for the past 10 years (actually 27 years if one goes back to the Aspen Institute's "Public Understanding of the Role of Science" effort), remains available as a utility infielder.

PROJECT DESCRIPTION-POLICY DIALOGUE PARTICIPANTS

The Keystone Center will invite participants from industry, government, academia, the Congress and interested organizations to take part in the meetings in the three series. For each meeting, they will be selected for the background and expertise they can bring to the discussions. They will also be selected on the basis of the likelihood that they might influence the use of the products of the discussions in the formulation of policy.

To provide continuity, a 'core group' of some twenty individuals representative of all these interests will be invited and encouraged to participate in all the meetings. The core group will be built on the participants in the first two planning meetings, augmented by a few others as needed.

A list of possible participants has been developed by the two planning sessions and is attached as Appendix B. Not all of these will be invited, and of those invited not all will be able to make the time commitment necessary to participate. They are included here to indicate the sorts of individuals who will be sought for the consensus dialogues.

WORK PLAN-SCHEDULE

The Keystone Center is prepared to begin the project in the summer of 1988 with the first of the meetings on strategic policy. This meeting can be followed on a schedule of about once a quarter with the other meetings in the three series. A final meeting could be held in about a year and one half to synthesize the results of the three series, completing the project.

The schedule for the project is shown in the figure below. It assumes three meetings in the strategic policy series, two in the technology transfer series, and one in the education series. If additional meetings are required to reach conclusions and consensus, they can be added, extending the schedule accordingly.

	1988			1989			1990
MEETING	Summer	Fall	Winter	Spring	Summer	Fall	Winter
1)STRATEGIC POLICY	X	X			X		
2)TECHNOLOGY TRANSFER			X			X	
3)EDUCATION				X			
4)SUMMARY SESSION							X

APPENDIX A

PARTICIPANTS AT THE TWO KEYSTONE MEETINGS

Dr. Robert Ayres	Carnegie-Mellon University
Dr. George Bell	Los Alamos National Laboratory
Dr. William Bishop	Science Applications International Corp.
Dr. Ronald Cape	Cetus Corporation
Dr. Peter Carruthers	University of Arizona
Dr. Ralph Christoffersen	The Upjohn Company
Dr. George Cowan	The Santa Fe Institute
Mr. Robert Craig	The Keystone Center
Mr. John Ehrmann	The Keystone Center
Dr. Paul Fishbane	University of Virginia
Dr. Fred Fox	University of California at Los Angeles
Ms. Mary Gant	National Institutes of Health
Mr. Charles Hancock, Esq.	American Society of Biological Chemists
Dr. Leonard Harris	NASA
Dr. Eric Hartwig	Office of Naval Research
Dr. Willard Hedden	The Keystone Center
Dr. Charles Hollister	Woods Hole Oceanographic Institution
Dr. Klaus Mai	Shell Oil Company
Dr. Sidney Meshkov	National Bureau of Standards
Dr. Marvin Moss	Scripps Oceanographic Institution
Dr. Stephen Nelson	American Association for the Advancement of Science
Dr. Arthur Nowell	University of Washington
Mr. Robert Rosenberg	Managing Editor of the Edison Papers
Dr. Leslie Russell	Committee on Energy and Commerce, U.S. Congress
Dr. George Stranahan	Physicist, Rancher, Entrepeneur
Dr. Rudi Schmid	University of California
Mr. Anthony Scoville	Committee on Science and Technology, U.S. House of Representatives
Mr. Albert Sobey	General Motors Corporation
Dr. Tisch Vajta	Lockheed Missiles and Space Co.
Mr. Del Williams	Argo Systems

APPENDIX B

SUGGESTED PARTICIPANTS FOR PLENARY SESSIONS

Lew Allen, Jr.	California Institute of Technology and the Jet Propulsion Lab
Robert Barker	Cornell University
Allen Birman	Miami University
Lewis Branscomb	Kennedy School, Harvard University
Harvey Brooks	Harvard University
Howard Chalkman	American Society of Biological Chemists
Ed David	Former President Exxon Research, Former Science Advisor
Dick Delaur	The Orion Group
John Deutsch	Science Applications International Corp., Massachusetts Institute of Technology
Craig Dorman	U.S. Navy
Ed Freeman	White House Science Committee
Don Fuqua	U.S. House of Representatives
Paul Gillman	Senator Domenici's staff
George Hatsopolous	First Boston Corporation
William Hewlett	Hewlett-Packard
Bill Hittinger	Lehigh University
John Holmfeld	U.S. House of Representatives, Science and Technology Committee
Grace Hopper	U.S. Navy Retired
Bobby Inman	Formerly MCC
Donald Kennedy	Stanford University
Dick Mallow	House Appropriations Committee
Lynne Margolis	
Thomas Murran	Westinghouse-Carnegie-Mellon
Norine Noonan	Office of Management and Budget
Charles Parry	Alcoa Aluminum
William Perry	Hambrecht and Quist
Fred Star	Oberlin College
Ed Trivelpiece	Office of Energy Resources, Department of Energy
Lucius Walker	Howard University
Marina Whitman	General Motors
John Young	Hewlett-Packard

APPENDIX C

ADDITIONAL PARTICIPANTS SUGGESTED IN FIRST STEERING MEETING

Robert Adams	Smithsonian Institute
Frederick Atkinson	University of California, San Diego
Arnold Beckman	Beckman Instruments
Victoria Chenkell	
Walter Cronkite	Scientists Institute for Public Information
William Dresselhaus	American Physical Society
Louis Fernandez	Calgene Corporation
Alexander Flax	Former President of Institute for Defense Analysis, retired
Donald Frederickson	Hughes Medical Foundation
William Gleick	New York Sunday Times
Marvin Goldberger	Institute of Advanced Studies, Princeton
Andrew J. Goodpaster	Former Supreme Commander, NATO
Bernadine Healey	Formerly OSTP; Cleveland Clinic/Western Reserve University
Gar Kaganowich	Federated Association of Experimental Biologists
George Keyworth	Former Science Advisor to the President
Daniel Koshland	Science Magazine
Wilbert Lepkowski	Chemical and Engineering News, ACS
Hugh Loweth	Retired from Office of Management and Business
Edwin Mansfield	University of Pennsylvania
David Martin	Genetech
William McElroy	University of California, San Diego
John McTague	Office of Science and Technology Policy
Quigg Newton	Commonwealth Foundation
William Nierenburg	Scripps Oceanographic Institution
David Packard	Hewlett Packard Company
Arno Allan Penzias	Bell Labs
William Press	Harvard University
Arthur Robinson	National Jewish Hospital
William Ruckelshaus	Environmental Protection Agency
Eugene Skolinkoff	Massachusetts Institute of Technology
Grant Thompson	League of Women Voters
Shield Widnall	American Association for the Advancement of Science

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The results of a policy consensus dialogue, planned and facilitated by The Keystone Center, to address the fundamental concerns related to the impact of science and technology R&D on U.S. life comprise the body of the report.

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